Bermuda 1-2
Gulf Stream Note No 2
May 11, 2009
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With less than a month to go until the start of the 2009 Bermuda 1-2 it's time for all competitors to begin a methodical study of the Gulf Stream and weather making full use of the variety of sources available on the web. Use of these over the past two months would have provided graphic illustration of several of the factors discussed in my March 4th Note. First, the past two months have seen relatively few cloud free days during which the position and form of the northern limits of the Gulf Stream in the vicinity of the Newport-Bermuda Rhumb Line could be accurately defined. For several weeks only brief glimpses of portions of the sea surface were available allowing, at best, development of composite views of the Stream. Due to the extent of the cloud cover, however, the accuracy of these composites was often compromised resulting in displays that were largely artifacts of the compositing process. An example of this is shown in Figure 1 where the Stream as it crosses the Rhumb Line is shown as a series of fragments rather than anything like the discrete boundary found several days later when the clouds lifted (see http://rucool.marine.rutgers.edu/). This fragmentation is simply the result of the character of the views available. At no time during this day was a clear view available. The optical averaging used in the compositing process was working only with "fragments" and as a result yielded the fragmented view. This points to the need to use care in evaluation of the utility of composite images.

The second characteristic clearly shown over the past two months was the meandering nature of the Stream in the area east of Cape Hatteras across the Rhumb Line and the associated rates of migration. In late February the northern edge of the Stream contained several large amplitude meanders with some number of bordering rings or eddies (see Fig.1 Note No. 1). Through the month of March the meanders in the main body of the Stream migrated progressively to the east at a rate of approximately 2nm/day. This migration affected both the position of the northern limit of the Stream along the Rhumb Line (i.e. the point where the Stream is first encountered) and the direction of flow across the Rhumb Line. The latter varied progressively from northwest to southeast to west to east to southwest to northeast as the feature passed by the Rhumb Line. Following passage of the western most meander in early April the Stream between Hatteras and the Rhumb Line straightened and has shown minimal tendency to meander through the month of April. It seems unlikely that this condition will prevail for much longer.

Since early May the satellite sea surface temperature observations indicate that the Gulf Stream near the Rhumb Line has maintained a nearly linear and featureless southwest to northeast track crossing the Line at a right angle. A clear view of the Stream received this morning (Fig.2) indicates that the northern limit of the Stream is located approximately 240nm southeast of Newport near 38^{o} N 68^{o} 30'W. This shows as an abrupt increase in sea surface temperatures with values increasing from approximately 17-18^{o}C to more than 25^{o} C. Although there is an abundance of disorganized small scale thermal features north of the Stream to 40^{o} N only one feature near 67^{o} W appears sufficient to produce energetic flows. If free of Stream influence this feature may drift to the west over the next few weeks and bears watching.

The USN thermal analysis (Fig.3) shows more of a meander in the main body of the Stream to the west of the Rhumb Line than indicated by the satellite image (i.e. Fig. 2) and also shows the thermal feature to the east as a warm core eddy or ring. Those competitors relying on the Navy data due to its relatively small file size and associated download time should carefully compare these two versions of the Stream in order to determine the extent to which the Navy data is affected by an analyst's interpretation. This might be a useful adjunct to the tracking of the thermal feature and the development of any meanders in the main body of the Stream.

As previously discussed, the variations in water temperature associated with the Gulf Stream affect water column densities much in the way that variations in air temperature affect atmospheric densities. And just as atmospheric densities affect barometric pressure and pressure distributions which ultimately produce air flows or winds, the variations in water column densities affect water flows or currents. The extent to which this occurs however, is difficult to accurately define using only water temperatures. A more promising technique makes use of satellite observations to define the height of water column above a given reference surface since the expansion of water produced by warming makes warm water columns slightly "taller" than cold water columns. This difference in height also produces pressure gradients that induce flow. In addition to its potential to provide accurate estimates of flow this satellite altimetry is an all weather technique capable of providing surface flow estimates in the presence of clouds. If the cloud cover observed over the past few months was to persist through May these altimetry data may be of particular value in Race planning.

An examination of the altimetry data for May 10 (Fig. 4) shows the main body of the Stream crossing the Rhumb Line from the southwest to northeast on a slightly oblique angle sufficient to produce some adverse flows along the track to Bermuda. The altimetry data indicate that Stream flows in excess of 1 knot will be encountered near 39^{o} N or slightly north and west of the thermal boundary shown in the satellite image (Fig.2). The altimetry also shows more meandering in the Stream west of the Rhumb Line and a warm core feature to the east. This latter feature does not appear to be free of Stream influence however, suggesting that it will migrate to the east over the next few weeks. Since the altimetry data show this feature already affecting a portion of the Rhumb Line it clearly bears watching.

To the southeast of the main body of the Stream towards Bermuda the altimetry data show little in the way of organized flows Only in the vicinity of Bermuda is there a well defined ring (cold core) producing a counterclockwise rotation with favorable flows along the Rhumb Line (Fig. 4). The current field associated with this feature as well as the structure of the flow field and the location of the highest speed currents in the main body of the Stream shows clearly on a contrasting image of the altimetry data showing both the currents and the associated velocity field (Fig.5 notice red arrow.).

To summarize, review of a variety of Gulf Stream and flow data suggests that, weather permitting, a sail to Bermuda starting today would follow a track in close proximity to the Rhumb Line. Overall a track west of the Line appears favors. This would accommodate the easterly set through the main body of the Stream and the smaller easterly flows in the area south of the Stream shown by the altimetry. It would also take full advantage of the cold core feature just north of Bermuda allowing a nice reach into St. David's on the forecast-prevailing southwesterly (?). Of course it's likely that these conditions will change substantially before June 5. The extent to which this change occurs can be nicely monitored using the combination of satellite sea surface temperature and altimetry available on the web. Remembering the extent of cloud cover over the past two months realization of the full value of these observations may require a relatively long period of observation. With the start of the Race in early June an immediate start of these observations may be none too soon.

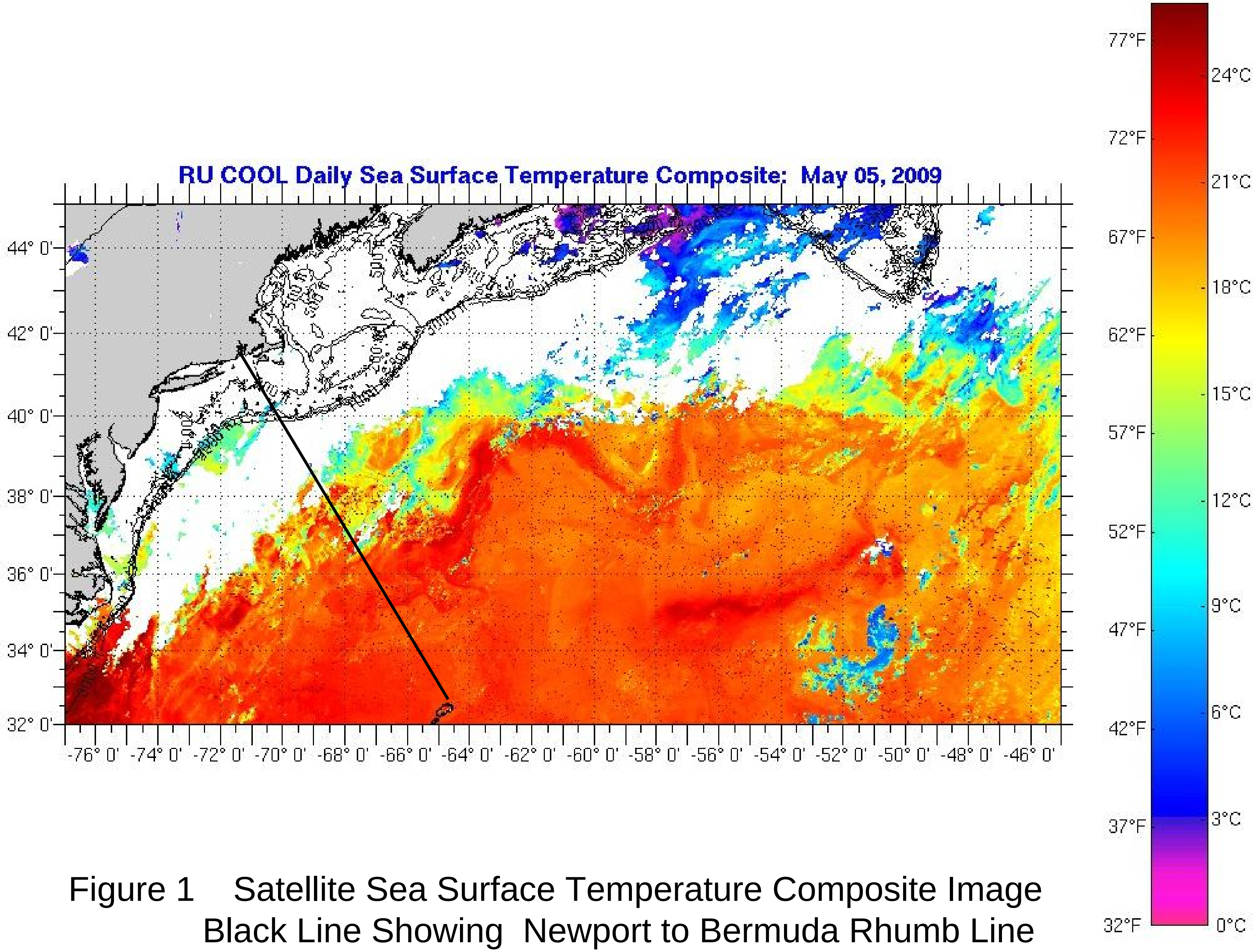

Figure 1 Satellite Sea Surface Temperature Composite Image
Black Line Showing Newport to Bermuda Rhumb Line
From: http://marine.rutgers.edu

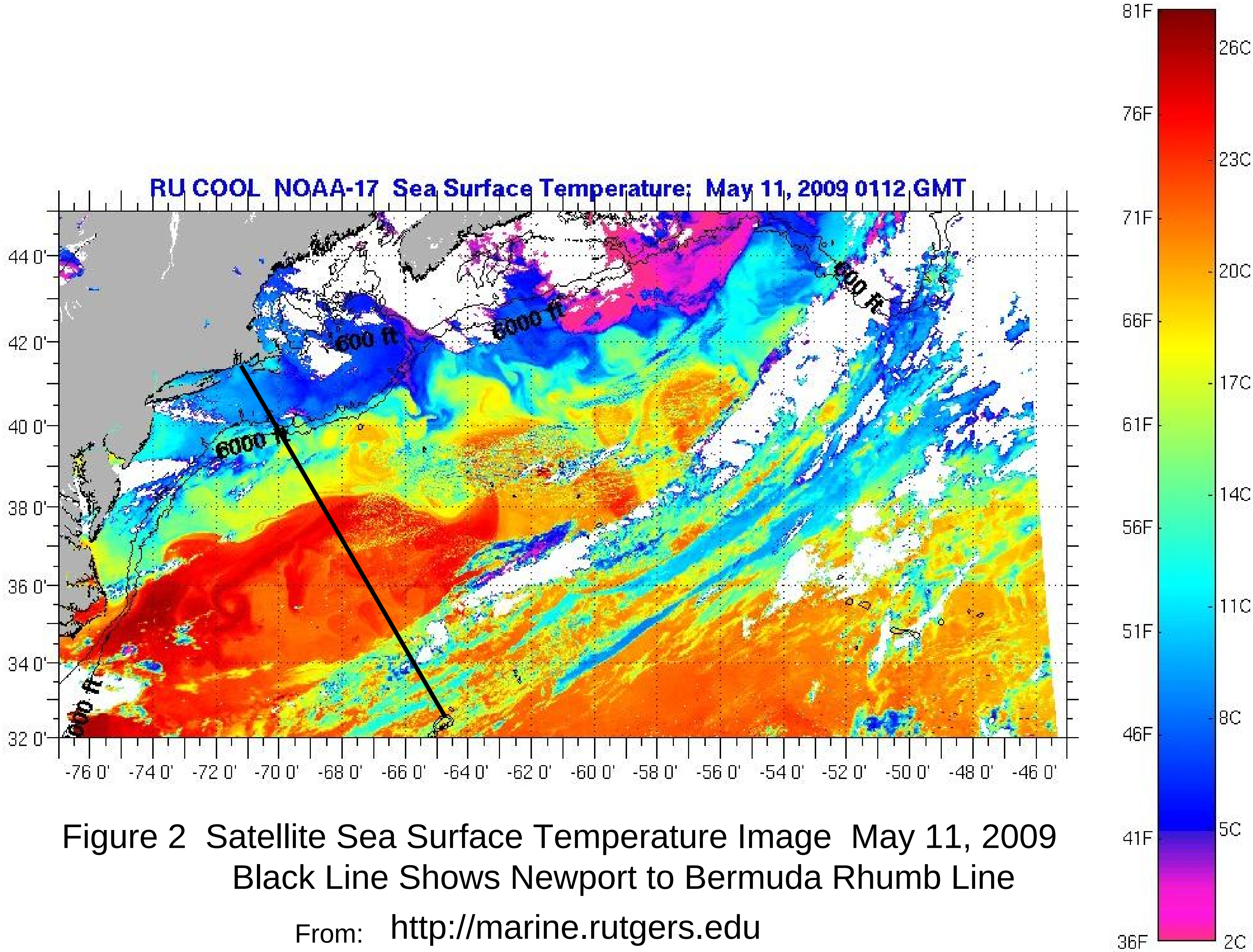

Figure 2 Satellite Sea Surface Temperature Image May 11, 2009
Black Line Shows Newport to Bermuda Rhumb Line

From: http://marine.rutgers.edu

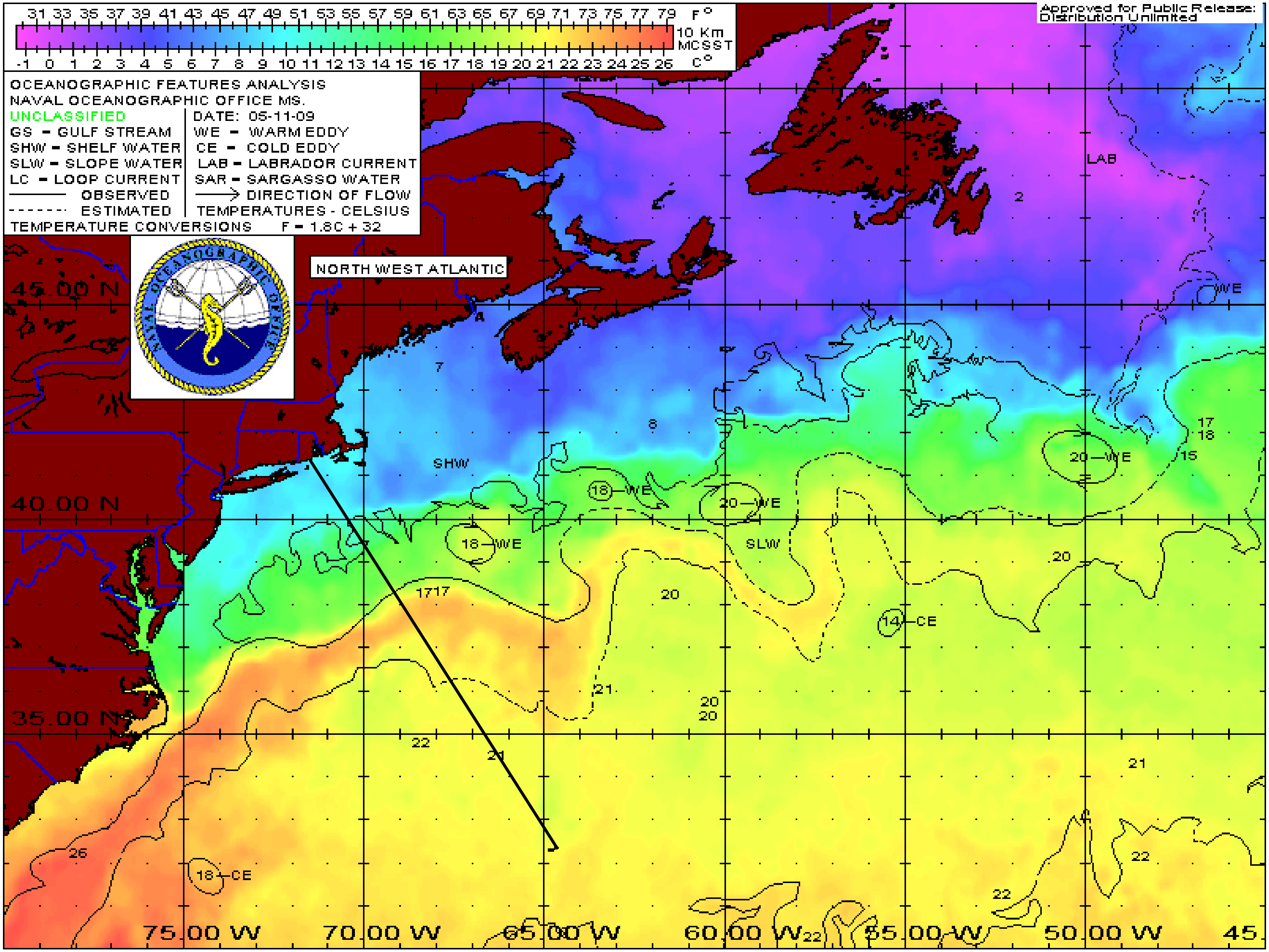

Figure 3 U.S. Navy Sea Surface Temperature Analysis May 11,2009

From:http://www.weatherimages.org/data/imag143.html

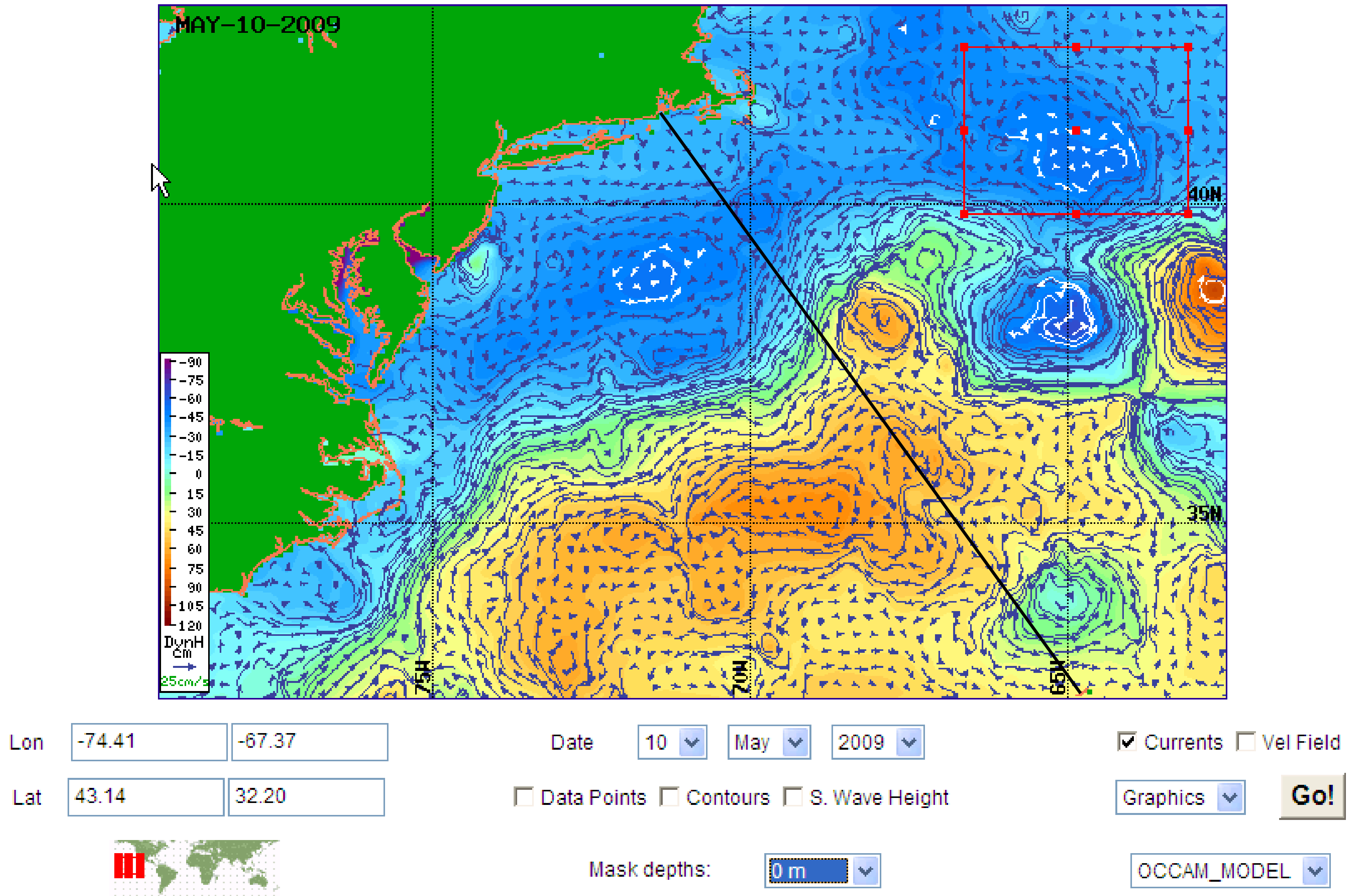

Figure 4 Satellite Altimetry Derived Surface Currents – NW Atlantic Region

Source:http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html

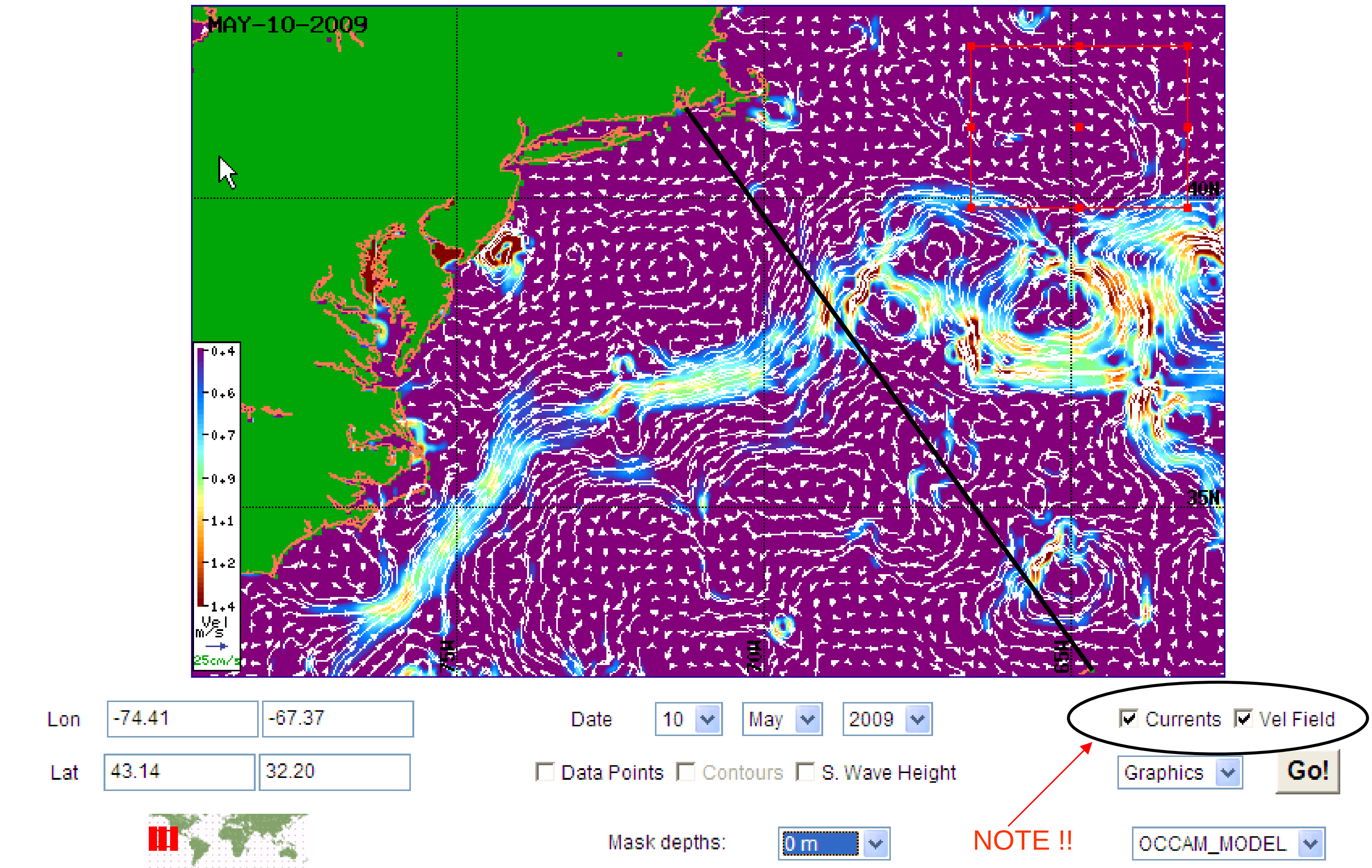

Figure 5 Satellite Altimetry Derived Surface Currents and Velocity Field

Source:http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html